EVALUATION OF A VARIABLE RATE LIQUID FERTILIZER FOR SITE SPECIFIC APPLICATION

ARZHANG JAVADĪ1, BEHZAD BEHZADI MACKVANDI2

1Associate Prof., Islamic Azad University, Dezful branch, Dezful, Iran, Email2arzhang@yahoo.com
2Researcher, Education department of AREEO, Karaj, Iran

CSBE100378 – Presented at Section III: Equipment Engineering for Plant Production Conference

ABSTRACT Applying new methods in the management of agricultural products is essential particularly in recent direction of precision farming. The aim of this study was to distribute chemical fertilizer based on site specific requirement. Therefore local data related to the quantity of soil nitrogen was mapped and places with sufficient or lack of nitrogen identified. The sprinkler was set to become active and inactive based on the map. Also sprinkler rate was varied by using encoder shaft. The farm selected for field test was divided into 12 plots of 2*5m² of which six allocated to specific rates and six for even distribution of fertilizer. The results based on acquired data indicated 58% reduction in the fertilizer consumption by variable rate compared to common method with even distribution. Also error rate of sprinkling test was 1.32% and 1.58% in laboratory and farm tests respectively. It was noted there was 8% reduction of fertilizer consumption in speed active status. Hence this method can be considered to significantly reduce fertilizers use.

Keywords: Geographical data system, Variable rate fertilizing, Fertilizer's distribution, Site specific management

INTRODUCTION The philosophy of precise agriculture is application of inputs such as fertilizer, pesticide and etc according to the requirement of each farm section. Variable rate technology (VRT) is managerial guideline for involving local variability changeability of the farm. In other word, VRT is optimal allocation of production's inputs. For instance in common method for applying fertilizer for instance, farm and crop consider invariable and the rate is determined based on soil productivity analysis. The medium rate of fertilizing (the volume of fertilizer per hectare) is distributed on the farm evenly (Paz et al, 1999). Common method with even distribution of chemical fertilizers can cause harmful effects in terms of social, economical and environmental issues. The signification amount of chemical fertilizers penetrates underground and pollutes waters without absorbing by plants and cause contamination of the environment (Fleming and Westfall, 2000). Also high levels of nitrogen in lakes endanger the lives of aquatics. Limitation of fertilizing to the places of the farm which are in shortage of organic materials can be remarkably economical in the volume of fertilizer's consumption. For instance in corn production, chemical fertilizer is one fourth of cash expenses. Abedi (2001) studied contamination of underground waters in Isfahan (central) region of Iran.
Their results showed that nitrogen volume in underground waters of 90% wells was more than standard. This outcome is considered as a guideline for optimizing the volume of chemical fertilizer's consumption. Welsh et al (2002) used the method of nitrogen application by variable volume on the farm of winter barley and wheat. The value of operations increased 0.36 and 0.46 ton per hectare compared to even distribution of fertilizer. Qazvini et al (2006) investigated local changes of soil productivity factors and function of wheat seed by applying variogram, GPS and GIS and produced digital maps in 5*5 blocks for applying variable rate by machines. These maps indicated that by overall sprinkling of urea, only 13% of the farm's surface received the sufficient volume and the other parts received less or more than requirement. Whereas, by VRT method, urea consumption was decreased at least 52 kg/h. Additionally, by overall sprinkling of phosphor and potash only 25% and 11% of the farm's surface received sufficient fertilizer respectively. Paz et al (1999) indicated that the level of nitrogen can be reduced. However, there was more production for evenly operation. They applied this method in Iowa state at Cornfield. The mean for the rate of fertilizer's application toward even distribution reduced 11 kg/ha and crop yield increased 97 kg/ha as well as 15.66 USD increase of benefit. Ulson et al (2002). Considered intellectual system of fertilizer's operation by two nerve networks. They estimated output of the first nerve system of operation's rate in accordance with the GPS coordinates and output of the second nerve network of flow rate. Rate of fertilizer's flow was controlled through the circular valve by electrical function. The main aspect of this research was prompt response of the system. The aim of this study was designing and developing a variable rate fertilizer by using GIS, GPS and VRT in order to distribute proper volume of fertilizer on farm surface.

MATERIALS AND METHODS

The research conducted at the education center farm 5 km west of Karaj (Figure 1).

Figure 1. Geographical location of the project execution

The map was prepared at first stage to indicate soil's nitrogen variation. For preparing soil productivity map, the common method is network sampling of the soil. But as the method of network sampling was expensive, the estimated data method of nitrogen volume was applied. Hence location of four corners of the farm was acquired by GPS map 60CSX. In order to minimize the GPS error four corners stabilized by Newo camera and then geographical location of theses four points were determined by GPS. During the data
collection there were 12 satellites accessible on the earth which increase the resolution and precise of data collecting. By selection of mark key on the device, one point will be registered. Number of require satellites for registration are 3 and minimum accessible satellite should be 6. After that the collection of information can be started. The data was processed by Arc view GIS software. Data related to the nitrogen volume of the soil and local data related to them created the map of soil nitrogen. According to recommended nitrogen volume required for the region the proper volume set in Arc view GIS software. The produced map was considered for the management of fertilizer's operation. Land was divided into 2*2 networks in the map which allowed to manage fertilizer operation a meter by meter. The prepared soil's map was converted to digital ones and sent to micro controller through output port of the computer. Finally according to the map, fertilizing operation was executed. An encoder shaft was used for coupling the map and locating of the machine on the farm for fertilizer's distribution. The device allows easy calibration, standard output and capability of installation over different wheel's diagonal. For connecting shaft encoder to the internal section of the wheel shaft, one elastic cylinder was used to avoid lateral rotation of the tire and damage. Also, it was installed on front wheel to prevent slippage effect on data (Figure 2).

![Figure 2. Locating of encoder on the front wheel shaft](image)

The pulse sent from the encoder for each 2 meters of front wheel movement acquired in the farm. The sent pulse reported the location of machine in the farm meter and sent as input of the designed electronic circuit. This was coupled by the fertilizer's operation map in micro controller. The data related to location of the machine in farm and volume of required nitrogen was coupled to each other and its output stimulated magnetic valve of variable rate. The required assumed data was extracted as a 100*6 matrix by one of the software function and installed on the electronic circuit of an LCD which indicated the volume of output voltage, valve's opening, number and location of the terrace. A controlling valve was used by the magnetic function. The volume of its output was in accordance with given direct voltage and could be varied from 0 to 100 percent. One of the most important features of valve was linear relation between the given voltages by the position of the valve's hatch (see figure 3).
The valve distributed proper value of the sprinkling rate according to considered place on the land. General sketch of the used system is shown in figure 4.

Before conducting test in the farm, accuracy of the device, delay value and speed were determined. The evaluation was done in laboratory by virtual networks on the firm road as well as real networks in the farm. In this research the parameter of fertilizer consumption was compared in both methods of fertilizer application. Moreover the precise and error of the device's operation in each special local terrace in both laboratorial and farm tests were determined. After the execution of tests and registration of the information, data were analyzed.

**RESULTS AND DISSCUSSION** The volume of fertilizing: comparison the mean of liquid fertilizer consumption in terraces by special local distribution and even distribution are shown in figure 5.
It was clear that for the method of special local application of liquid fertilizer there is 58.34 percent economical. Figure 6 indicates the comparison between fertilizing application in both methods in each 6 terraces.

Increase or decrease for the consumed fertilizer in special local operation depends on the volume of required fertilizer for the soil. Whereas, the volume of the consumed fertilizer is stable in the special fertilizing operation and it does not depend on the nitrogen changes. The precision of the device was found to be highly depended on the proper encoder shaft function, due to valve reactions in less than 1 second and required rate. The reasons of error in sent data from encoder shaft was noted to be as firstly slippage of encoder shaft on the internal section of shaft which causes late operation delay secondly vibration of the truck, and creating additional pulse in the circuit of the encoder, causes early operation. The mean of the error in the laboratorial section was 1.32 percent. It means that only 66 cm of 50 meters which was under the operation received rate apart from considered rate. Error in laboratorial test was because of the slippage of encoder shaft but in farm test was due to unevenness of the land and low sensitivity of encoder shaft to the vibrations. The mean of the error in farm test was 1.58 percent; it means that only 79 cm of the total terrace received rate apart from the considered rate. However, the volume of the variable rate valve's opening was shown on the installed LCD on the circuit. The volume of liquid from each dropper was collected by a one-litre beaker in 30 seconds. The data of these two parameters were studied for evaluation of their linear form. Relation between these two parameters is shown in figure 7.
Figure 7. Relation between the variable rate valve's opening and its output dobbly

REFERENCES